

EXPLODING BOTTLES

CRAIG SPANGENBERG*

In the class of cases of exploding bottles, there is no real room for debate as to whether a particular individual is or is not unduly sensitized or allergic, because no eyeball resists well a flying splinter of broken glass. The glass container which encloses a liquid under pressure, charged with carbonic acid gas, is a potential bomb—and must be viewed as such. When a container fails, gas released from pressure will expand rapidly to its normal volume and the force of this expansion will not only produce the characteristic loud noise which explains the term exploding bottle, but will also throw fragments of glass with considerable force for twenty or thirty feet. The force of flying glass splinters is adequate to sever a tendon, to slice through an artery, or to transfix an eyeball.

Our primary interest is in the carbonated beverage, and we are not so much concerned with the inclusion of cockroaches, dead mice, moldy peanuts, and various things that make people who drink them nauseated, although the experts from the bottling industry will assure you that they are perfectly wholesome by the time they reach you, having been duly pasteurized. We will deal with the product which we will assume is wholesome, and with substantially normal gas pressures. That is, if the mouse isn't adequately pasteurized it may produce fermentation which will increase the gas pressure so that there is a highly charged, mouse-filled bottle. Now it is quite possible in the beer industry to have the brew reach the bottle with a little unfermented sugar and a little live yeast in it. If so, fermentation will continue with an addition of natural carbonic acid gas, resulting in a high-pressure bottle. If this happens with beer, it will mean that the whole run has been so affected and there will be many bottles which explode. Investigation in this situation must include a run through all the beverage stores in town which handle this beer to see if there has been an unusual number of bottles exploding in the back room, which will be some evidence of a defect in the pasteurizing oven that has allowed fermentation to continue. This is a fairly rare case. However, it can happen and your investigation should run down this point if the product involved is beer.

With respect to other products, let us begin not at the beginning, which is the manufacture of the bottle, but with the bottler who is usually the primary defendant. We will go through a bottling plant to give you some understanding of what defenses will be raised, such as

* Of the firm of Spangenberg, Hasenflue and Shibley, Cleveland, Ohio.

production tests and inspection; and to give you some idea of how you might meet the theory that production itself is an adequate inspection of the bottle. We start with return bottles brought back in cases. They are dirty and contain all manner of materials that children put into the bottles, such as marbles, stones, peanuts, or clothespins. Sometimes they even contain small animals from the basement that have made the bottle a home. These bottles, stored in cases, are normally fed by hand into the beginning of the production process, and this is called the inspection. You should understand though that the man who is feeding bottles into the beginning rack, out of the case, usually wears gloves to protect himself against sharp edges and cuts, and takes four bottles at a time—two in each hand—as quickly as he can move his arms, pulling them out of the case and putting them on the rack. This is an “inspection” only in the sense that if the bottle is broken in two, he will lift only a neck which he will not put on the rack. Most of the bottles are used. New ones are fed into the process only to replace losses in service, breakage in service, bottles that for some reason were not returned for years, or because of an increase in production. The new bottles will have been tested by the manufacturer in a limited fashion. Return bottles are, by industry practice, not inspected at all. The theory is that production itself will be an adequate test.

From the initial conveyor, the bottles will go into washing equipment where they are given a soaking treatment in a fairly hot caustic or detergent which soaks off the label, if it is a gum label, and loosens the material and dirt in the bottle. This initial hot soap by itself constitutes a thermal shock—but a mild one—not as severe as the bottle will get later when it's taken out of the hot sun where it has been standing and thrown into a tub of ice water on the Fourth of July picnic. This initial contact between the hot soaking solution and the bottle at room temperature will cause the fracture or breakage of bottles which are already cracked, and therefore already weakened and unable to withstand even this mild shock.

The bottle then goes to the washing machine, and it may be a matter of intellectual curiosity to you as to how the mouse gets into the Coca-Cola bottle, since the Coca-Cola bottle itself is filled from a tube with about a quarter of an inch diameter—too small to pass the mouse. This is easy to explain. The mouse was in the bottle when it came back to the plant. After the bottle has been rinsed and soaked, it goes to the washing machine where a rotating brush is put in the bottle. The bottle is then upended, the brush spins, and a jet of washing fluid is shot up into the bottle. Since the spindle of the brush fills a substantial part of the neck of the bottle, all that will come out are

particles small enough to fit into the gap between the neck and the spindle. The bottle is then dumped down, goes along the rack to the rinsing machine, where again a tube is put in it, the bottle is upended, the tube squirts water which rinses it, the bottle is turned over, and away it goes. Anything inside the bottle which is larger than the small gap left between the tube and the neck of the bottle, will remain in the bottle. In theory, larger materials will be picked up on inspection at the end of the line, or they may be picked up by the inspector who stands by the conveyor line as the bottle goes to the filling machine, if someone is stationed there. This inspector is used in some plants on the empty bottles, but not in all of them by any means. I think the important thing to know about the washing process is that this accounts for most of the liability cases that the attorney encounters. The cases that can be won are chiefly cases of bottles which break because of internal damage. And this damage comes either from objects forced into the bottle when they are in the hands of the public or from the spindles and brushes of the washing process itself. The prime source of internal damage is from the bottler's own washing equipment. Some glasses break while they are being brushed with this rotating brush, particles of glass may be caught in the bristles and then, until the particles themselves are worn out or torn out, succeeding bottles will be brushed with spinning sharp glass particles which can easily damage the inside of the glass with small scratches and nicks.

The carbonation process is not done in the bottle; it is done in the beverage. When the beverage has been mixed, it is stored in a tank where it is carbonated. The characteristics of carbon dioxide gas are common to most gases. If the gas is a soluble one, ordinarily, the greater the volume to be captured, the lower the temperature of the solution must be. Or to state it another way, the lower the temperature of the solution, the greater the volume of gas that can be held in solution. Therefore, whether Coca-Cola, 7-Up, or beer, the beverage will be stored in a tank in a cool condition in order to retain its carbonation. Another rule of gases that applies is the greater the pressure, the smaller the volume of the gas. In the case of a gas in solution in a liquid, the greater the pressure, the greater the total amount of gas in solution. A "volume" of gas is a technical term. This is a measure of gas assuming one pint bottle. One volume of gas for that bottle would be one pint of gas, assuming the gas is at mean sea level pressure of about 14.6 pounds per square inch, and at 32 degrees Fahrenheit. The standard pressures in the carbonated beverages are: Fruit drinks, such as orange pop, grape pop, etc.—18 pounds per square inch at 60 degrees Fahrenheit; Beer—24 pounds per square inch at 60 degrees Fahrenheit; Cola drinks—about 38 pounds per

square inch pressure at 60 degrees. Ginger ale and 7-Up run higher—46 pounds per square inch; but the real high pressure product is club soda which normally runs about 60 pounds per square inch pressure at 60 degrees.

Because of the rule that volume and pressure of beverages are affected by temperature, you should realize that the pressures stated will double at about 98 degrees Fahrenheit, so that beer bottled at 24 psi will reach about 50 psi at a hundred degrees, which is the temperature it readily attains when sitting on the window sill in the sun. When that beer is put in a cold ice box, it is put in under high pressure and a thermal shock may then cause fracture which would not occur if the beer were at ordinary room temperature. The beer has a test put to it during its manufacturing process in that it is always pasteurized at about 140 degrees Fahrenheit. This increases the pressure in the beer bottle to about 88 pounds per square inch, and this is a great test of beer bottles. If you should ever stand beside a pasteurizing machine, it will remind you of a popcorn popper, as you hear the bottles explode while going through the process. These are bottles which have been abused in use or have developed weaknesses to the extent that they cannot stand the pressure that is generated in pasteurization. But this is an incomplete test as will become apparent if you stand by the line of bottles coming out of the pasteurizing process and going before the inspector. At that point in the line, bottles still explode. In fact, they often explode in front of the inspector, more explode beyond the inspector, and more explode in the labeling machine when an arm comes out and slaps a wet label on the bottle with relatively slight impact. More bottles explode as they are put into the cases, and more explode on the trucks; so that pasteurization is not a complete guarantee that the bottles will not later explode.

One other peculiarity of the gas with which we are dealing is its response to agitation. It tends to become supersaturated in solution, so that even though the temperature rises, not as much gas escapes from the liquid to go out of solution and occupy the head space between the top of the liquid and the cap as would be supposed in an ideal state. When the liquid is agitated, the supersaturated gas comes out of solution quite rapidly. This is a scientific fact known to every small boy who ever shook a bottle of root beer with his thumb over the cap, and then squirted it thirty feet at some small playmate. In doing this, he is using the principle of agitation to release all the gas that is possible, which will increase the pressure in the bottle. This principle of agitation is probably the chief explanation of the many cases reported where people say the bottle was just standing there. "I picked it up, and as I lifted it, it exploded." Why should this slight motion explode

it? It is because the bottle has reached a point where it is at absolute equilibrium. It can stand no more pressure, and just the slight agitation of moving it will release the last half pound of pressure of gas which will be enough to cause the final fracture.

The amount of pressure in the bottle will depend, of course, upon the accuracy of the gauges and thermometer in the bottling process. My only knowledge about this comes from the writings of Professor Dingwall who says these gauges are seldom checked and not always highly accurate, so that it is possible to have an over-carbonated beverage through deficiencies in the manufacturing process, as well as through additional fermentation in the bottle. The usual approach to a case is that either the bottle was too weak or the pressure was too great. I think you should realize that in the normal production process, however, the differences in pressure are seldom significant enough to cause failure of a bottle. A bottle, even one that has been fairly abused, ought to stand about 150 pounds per square inch in pressure; but even under agitation and with heat, it is seldom that you can get a bottle of beer up above 50 or 60 pounds per square inch internal pressure. Club soda goes a little higher but the soda bottle is designed originally to stand higher pressure, so that it is seldom excessive pressure which explodes the bottle. It is rather a weakness in the bottle.

To complete the process, the bottles go to the filler, a preliminary shot of air is given to the bottle to equalize the pressure in the tank, the bottle then fills by gravity and is capped and the cap is crimped. This is said by the industry also to be a test of the bottle. Actually, it is only a test of the little finish at the neck that takes the pressure of the cap. It is sometimes cracked in the crimping, particularly if the neck is out of round in the finish, but the crimped cap will often hold the parts together until the user attempts to remove the cap. At this point, a bottle that has been cracked will readily explode as the crimping pressure of the cap is released. This can be demonstrated not to be a real test or to serve any real inspection function on the bottle.

You will note that the significant feature of pasteurization is that it is accompanied by little or no agitation. The beer is raised in a quiet state in the pasteurizer to its temperature and moves along a conveyor belt. The bottle is not struck; there is no impact, and there is no disturbance. Therefore, the pressure in the bottle is not likely to be the total pressure that would be computed theoretically because of the principle of super-saturation. When bottles explode after pasteurization, the chief reason is that glass is highly subject to the phenomenon of fatigue. It is stated that if a sheet of window glass is supported at the four corners with a modest weight in the center, although it could withstand a much greater weight for a short time—after a sufficiently

long period of time, the glass will shatter. It tires or weakens under loads. A second principle to bear in mind is the principle of stress concentration. Stress concentration is not peculiar to glass. It is a phenomenon exhibited by almost all materials. Let us assume that we have a bar of steel one inch square which is put into a stretching machine and pulled with a strength of 50,000 pounds. The engineer would tell you that the steel is under a tensile stress of 50,000 pounds per square inch. If that same steel bar is then notched, and the same stress is applied—the same kind of pull—the stress throughout the bar will be generally the same, but will be much higher at the root of the notch. The stress tends to flow in flow lines through the bar, and when these lines of stress reach the notch, or nick, or crack, they must deflect around it. As they do, they tend to pile up, much as water in a brook will pile up around the rocks in the brook, and the brook actually bulges higher. Now you can't see the stress bulging higher, but if you viewed a piece of plastic which was under stress and had a notch in it, under a polariscope, you could see the flow patterns very clearly and could see this phenomenon of stresses piling up at the edges of the discontinuity. This means that, although the general stress on the bar might be on the order of 50,000 pounds per square inch—at the very base of the crack the stresses may be increased anywhere from three-to-one to ten-to-one, depending on the sharpness of the notch and on the ability of the material to flow or yield and ease itself to reduce the sharpness. Glass will not flow or yield at all, so that a scratch in glass will produce very high stress concentrations at the bottom of any nick, and the sharper and narrower the scratch, the greater will be the concentration of stress. In the example that we have given here of a 50,000 pound per square inch general stress, at the foot of the notch you may be dealing with stresses in an intensely localized area of 500,000 pounds per square inch. If we have scratched material that is subject to fatigue and the stresses are increased by the phenomenon of stress concentrations, then the glass in that area may at any time fail and crack out to an unfatigued area. The crack itself is the sharpest possible notch, so that stress concentration repeats itself at the end of the crack, fatigue sets in, and the glass cracks. In this way, cracks propagate themselves. As a result, a fatigued bottle standing perfectly still may suddenly blow up. The principle of stress concentration is also of great importance if impact is added and if the impact is over the area of stress concentration. Therefore, an internal scratch in the bottle with pressure and fatigue build-up around the nick, plus impact on the outside in that immediate area is likely to produce explosion even though the impact is relatively slight.

Is any inspection made for this? The answer is no. There is a

formal inspection of the filled bottle in which the bottle is on a conveyor run in front of a light. An inspector sits there and supposedly looks at every single bottle—260 of them a minute. If he sneezes, ten of them go by uninspected. The job of this inspector is to see that the bottle is filled, because if it is not, the customer will complain. He can see the clothes pin, and the mice, and the cockroaches. He can see a bottle that is fizzing around the neck. He knows it is improperly capped. But in general, he is looking to see whether he has a cleaned bottle and a filled bottle and that is all. He could see a major crack but ordinarily the cracked bottle that is cracked through will not get past the final capping or the pasteurizer. But he will not see internal damage, and the reason for this is two-fold. If there is an internal crack and it is filled with 7-Up, then it can't be seen. It is visible only in an empty, dry bottle. When a used bottle is held up to the sunlight, the inside looks like a snow storm from internal nicks, but they cannot be seen when it is filled with liquid. Also, since the bottles do not rotate as they go past the inspector, if the nick is at right angles to the line of vision, it will be completely hidden because he is looking through the thickness of the glass, in the same way that an X-ray will not disclose a crack in the bone if it is at right angles to the rays as the X-ray tube is placed.

Following this inspection, there is labeling, packing, storage, and delivery, all of which produce some impact on the bottle and cause the breakage of more bottles—eliminating almost all the weak ones. The filled bottle finally gets out to the store and from the store to the customer. In the customer's hands, the causes of failure will be either abuse of the bottle, a weakness in the bottle, the building up of excessive pressure through uncontrolled fermentation, thermal shock, or a combination of these causes. The bottle may break in the customer's hand under conditions of thermal shock even though it is a completely undamaged bottle, but for a whole sound bottle to do this usually requires a manufacturing defect existing in the bottle in that the bottle glass contains inclusions of glass that is not homogeneous with its neighboring material. This does happen. The non-homogeneity is described as "cord." Cord may consist of thread or rope, depending on how big it is. It is a problem in the industry to produce bottles out of the bottling machine that will have a completely homogeneous composition. In addition to differences in the composition of the glass, there are times when stone and foreign objects get into the glass mix and are poured in the mold with the bottle. These ought to be seen either in the manufacturer's inspection or in plant inspection. In addition, there are problems with thick and thin spots in the wall. Here it is time to go back to the manufacturer.

The modern bottling industry depends on a basic invention which took glass blowing out of the class of a handcraft art into a machine product. Glass bottles now are made in one pass by a machine which sucks up a glob of glass and blows it into a mold. The mold shapes the bottle, and leaves marks of the mold on the bottle. That stripe you can see on any bottle is part of the manufacturing process and will have little, if anything, to do with the failure unless there is a defect in the mold which leaves a parting line of thick glass. A spot of thick glass will be under greater strain than its neighboring glass. The difference in the cooling rate as it comes out of the production process accounts for this. If the glass cooled rapidly at room temperature, it would be under such strain (because of differences in cooling rate) that just to touch it would make it explode. To avoid this, the glass is annealed in an annealing oven, and one of the standard tests in the industry is the polariscopic test to see whether annealing has left it with fairly uniform strain. It will still have some. If it were annealed soft it would never stand up in use, so it is annealed with enough hardness to take abuse, but not enough strain, it is hoped, so that it might explode. Probably the best control of internal strain is simply a production control through the temperature gauges on the annealing oven, because the standard test for annealing strains is to test one bottle from each mold cavity every three hours. That this is not a complete test will be readily apparent if you realize that the glass in the furnaces is never thoroughly homogeneous, and to test only one in 600 for annealing strains will not be a test for the inclusion of cords and seams. It is part of the standard of the glass industry now to spot test for thermal shock which will break a bottle much more readily if there are thick and thin spots or cords and seams in the glass which set up great strains from differences in the rate of heating, cooling, contraction and expansion in the glass.

How can you tell from the broken bottle what it was that caused the fracture? A very great deal can be told from the fracture pattern, and if all the particles of glass can be recaptured, then almost the whole story can be told. If, in the carbonated beverage container we can distinguish between the primary and secondary fracture lines and can distinguish between mild and severe impact, then surely we have gained a good deal of information that tells us whether we should be going against the manufacturer of the bottle or against the bottler of the beverage. The method for reconstruction of a bottle is to play a jigsaw puzzle game with the pieces; but first, each piece itself is carefully analyzed. The direction of propagation of the crack can normally be told by the fact that if you look at the fractured edge of the glass you will see a number of ribs. These ribs will have a concave and a

convex side. The direction of propagation is toward the concave side. The tail of the rib striking the surface would indicate the surface from which the crack propagated. When each piece has been studied, the expert will mark on it, with wax crayon, arrows showing the direction of travel of the fracture lines. It will also indicate from which surface they were moving. When this has been done, the pieces are carefully scotch taped together. The expert may then find a pattern consisting of a fairly straight vertical branching off and forking, much like the branches of a tree, upward into the bottle, and further radiating lines branching off like the roots of a tree toward the base of the bottle, with other lines cutting across those. Now the lines cutting across would be secondary lines. That means they were further fractures as the piece hit the floor and broke. The primary fracture lines that have been compared to a tree structure are quite typical of a break due primarily to internal pressures, that is, a bursting caused by pressures greater than the bottle can withstand. This may be a combination of mild impact plus internal pressure, or a crack that is growing and expanding, so that fatigue sets in ultimately to trigger the initial pressure pattern. There are other characteristics of that break. If you looked at the edge of one of the pieces of glass in cross-section, normally you would find a little nick in the glass at the site of the propagating crack; then a very bright mirror surface surrounding that with concentric rings of ribs, indicating the propagation outward; then an area called a matte area in which there are hackles which look like the feathered end on an arrow, and further indicate the direction of propagation.

If the fracture is due to an external blow, assuming now the kind of violence no bottle could take, the characteristic feature is the cone of percussion. At the point where the blow strikes the bottle, a cone of force is produced which knocks out a cone shaped piece of glass. The cone will seldom be found since it is very small, but the reconstructed bottle will show this cone on the inside surface. The area at the base of the cone would be on the inside surface. There would be a small spot at the outside marking the point of impact. The characteristic fracture lines away from that impact area are radiating lines like the spokes of a wheel. If the blow is near the bottom of the bottle, then there is a characteristic butterfly-shaped break—a piece of glass knocked out of the edge of the base. When the blow is a little higher, but near the base, there are half-moon fractures pointing downward. A blow well up at the shoulder produces half-moon fractures moving up. Sometimes a bottle breaks, not with this vertical fracture line, but with a horizontal one. That is characteristic of a simple tensile break in the bottle, and usually comes about as the result of some abnormal leverage strain

on the bottle. A classic case of that would be a bottle with a right angle shoulder, broken horizontally across the neck. If you have that, plus the chip out of the base, you would be pretty safe in saying that whoever handled the bottle had it by the neck and struck the base so that there was some leverage produced. The leverage was sufficient to make the bottle fall across the area where the stress was concentrated because of the design of the bottle, that is at the change in the cross-section of the bottle. The expert having all the pieces will be able to tell quite well why the particular bottle broke. This by itself will not prove that there is liability. Indeed, if the experts findings are that it broke simply through violence with a cone of percussion, the lawyer for the plaintiff might as well forget the law suit, even if the bottle had many defects. If the impact is great enough to produce an active percussion cone, that kind of impact would probably have caused any bottle to fail.

However, the fact that there is impact doesn't end the matter by any means, because the bottle in normal handling is supposed to take impact. We mentioned earlier the testing procedures used by the glass industry. They come about chiefly because of the early New York case of *Smith v. Peerless Glass Co.*,¹ which involved a bottle that was corded. The plaintiff's expert called these cord striations, which he said could be seen under a polariscope. The defense made was that although this would tend to make the bottle fail, the standard polariscopic test is only to spot check one of a great number of bottles, and to check them all would mean full inspection. The expert said that it is common in the industry to test the bottles for thermal shock and this would easily point out to the manufacturer the bottles that have ridges, cordiness and inclusions. Simply immerse them in hot water, and then in water 75 degrees Fahrenheit colder. If it is a defective bottle, it will break. Judgment was rendered for the plaintiff in that case, the court holding that if there was a test that is common in the industry to detect the state of strain from striations in the bottle, then the defendant was negligent in not using it.

A good many experts have criticized the case, but what they chiefly criticize is the testimony of the plaintiff's experts in the case, claiming that there never was a standard test. He merely said the industry used it, so the court said the industry ought to use it, resulting in industry use. But it broke a lot of bottles, and that is hard on production costs. The original test was a soak in hot water and then a dip in cold water, 75 degrees colder, but the present industry standard is designed just to do a test; not really to test much—but to

¹ 259 N.Y. 292, 181 N.E. 576 (1932).

say a test has been done. The present standard is such that there is no predetermined temperature differential. Each manufacturer can set up his own—whatever he thinks is adequate. He soaks in hot water and then lifts the basket of bottles and transfers them to the cooler water. The original test was a transfer within fifteen seconds. The present standard is between fifteen seconds and one minute, so that if too many bottles break in fifteen seconds, just let them air cool for about a minute before the immersion in colder water and not nearly as many will break. The present test does not have a great deal of meaning, but it satisfies the court requirement, as the industry views it, that some test be done. We would be much better off if industry took the money it spent on these tests and merely built up a fund to compensate the victims of blown up bottles.

There is another test—a simple pressure test. One bottle from each mold cavity in every three hours of production run is tested to see how much pressure it will stand and whether it will stand the minimum. Now this would be a valid test if every other bottle from that mold in that three-hour period were equally strong, but this is not true and industry knows it is not true. In the very nature of the production process, it could not be true. The differences in strength are striking. Tests on a series of bottles as they came from the mold produced pounds-per-square-inch breakage at ranges from 200 to 600.² That is a three-to-one difference in bottles. With this kind of range, the test of one bottle every three hours doesn't tell much. Another deficiency of the test is that the bottle holds the test pressure for a very short period of time, so that the test completely ignores the fatigue characteristic inherent in glass. Moreover, it tests a brand new bottle fresh from the mold, which is undamaged and has a perfect finish, and will tell the user very little about the strength of the bottle that is used and re-used before coming to him. The polariscopic test puts polarized light through the bottle. It shows annealing strains. Again, only one bottle from each mold cavity every three hours is given this test, and it is really a test of the efficiency of the annealing oven. It is not very important to the user whether this is done because there is so little chance of breakage from annealing strain in view of the other factors that cause explosion.

From the attorney's standpoint it may be, as the experts say,

² Teague & Blau, "Investigations of Stresses in Glass Bottles Under Internal Hydrostatic Pressure," 39 J. of Am. Cer. Soc. 229 (1956). For other pertinent and helpful work in the technical journal, see Ghering, "Improving the Strength of Glass Containers Through Design," 20 Glass Industry 443 (1939); Preston, "The Meaning of Testing Procedures," 22 Glass Industry 23 (1941); Preston, "Internal Surface Damage to Bottles," 33 Glass Industry 639 (1952).

that the tests are useless and a great burden on industry, but there is some ammunition for the plaintiff here. The manufacturer tests his bottle in this way, and says these tests are almost infallible and that the production process has become almost infallible: The machines turn out good bottles. The test verifies the fact that they have turned out good bottles. The manufacturer's expert is likely to say, "Our testing procedures are almost infallible in the detection of bottles that have annealing strains, cords or seams; or bottles which cannot take pressure. In fact we test them at pressures at least 50 per cent greater than the bottle is ever expected to receive in its normal life, so we have a built-in safety factor." If the manufacturer actually runs through these tests, then it is a valid argument that since the bottle will be changed by use, and since most of the bottles going through the bottler's machinery are used bottles, then the bottler ought to have the same kind of testing program. He should not test just one in 600 bottles because each bottle that goes out of the plant has a different service life. This would support an argument that the bottler ought to adopt some test method for every bottle he has, or failing this, stand the risk that he may be turning out a bottle which will cost the user the sight of an eye.

So much for technical aspects. Let us turn now to legal aspects; and observe at the outset that the only significant legal problem in these cases will turn on the application of the doctrine of *res ipsa loquitur*.³ In all other respects, the legal problems are the same as they are for threshing machines and children's play suits. The law is virtually the law of negligence or the law of warranty, without labeling it as product liability law. The manufacturer may be liable for negligence in the design of his bottle. The bottler may be liable for negligence in the design of the bottle. Occasionally, the bottler will want to distinguish his product on the market, so he designs a bottle with a fancy shape. The manufacturer builds the shape. It may be that the manufacturer ought to know that this is a very dangerous shape, and the bottler who has designed it or collaborated in the design also would be charged with this knowledge. The one completely dangerous shape in a bottle is an abrupt change in section. This is classic engineering. References to it in other fields go back to the 1860's. You have all probably seen, at some time or other, a bottle that is built with an almost square shoulder: the side wall rises to the shoulder, turns abruptly toward the neck and then swings very sharply into the neck. The glass industry generally recognizes this as a dangerous design because when

³ See 1 Frumer and Friedman, *Products Liability* §§ 26.02-.03 (1960); 2 Hursh, *American Law of Products Liability* §§ 16.06-.25 (1961); Annot., 4 A.L.R.2d 466 (1949); Night, "Let the Bottler Beware!," 21 *Ins. Counsel J.* 72 (1954).

there is an abrupt change in the cross-sectional area of a member through which stresses are passing, stresses will pile up at the change of section. The greater the change of section, the greater the pile-up of stress. A bottle is going to be handled normally by the neck. People pull them out of the case by the neck, handle them by the neck, and in uncapping, hold the bottle at the base and pry the cap lose so that there are leverage forces working through the neck. This handling and leverage action puts the neck into compression on one side, tension on the other. The square shouldered bottle, even without any imperfections, is very likely in normal use to develop a leverage fracture with mild impact. This is the one case, I think, where design negligence is easy to demonstrate. Dingwall suggests that there may be design negligence if the bottler so completely covers a bottle with a printed label, putting all the advertising copy on the bottle, that no one could ever inspect because the inspector can't see through the printing.⁴ I am not aware of any cases on that point, but one may come about. General law and liability for negligent design is well stated in metallurgical fields in the *Moran v. Pittsburgh-Des Moines Steel Co.* case,⁵ and in the *Northwest Airlines* case.⁶ Other types of manufacturer's negligence would be the production of a bottle with excessively thin spots in the side wall; production of a bottle with striations, cords and inclusions; and production of bottles with defects in the shape of the glass—that is a choke neck in which there is too much glass that remains in the neck so that there is a bulge. This choke neck bottle is very likely to be damaged by the spindles and brushes in the bottling process. A bottle that is out of round in the finish will be broken or cracked by the capping and crimping operation, as mentioned above. And this would be the manufacturer's negligence because it would be off standard. A bottle that has a tilted base, called in the industry a drunk, is also a hazardous bottle because when it goes on the conveyor line, it doesn't go into the brushes, spindles, cappers, and crimpers at the right angle, and so is quite likely to be damaged in production. If the bottle is a choke neck, out of round, or drunk, and the explosion is associated with that kind of defect, then the manufacturer should be questioned sharply about his design specifications and his tolerance on his own design blueprints. This is one of the easiest cases to win where the manufacturer's own blueprint, design and inspection standards are clearly violated by his product.

Is there any liability of a bottler in warranty? Well, I think we can answer that quickly. In Ohio, we haven't jumped the privacy gap

⁴ Dingwall, "Exploding Bottles," 11 NACCA L.J. 158 (1953).

⁵ 183 F.2d 467 (3d Cir. 1950).

⁶ *Northwest Airlines, Inc. v. Glenn L. Martin Co.*, 224 F.2d 120 (6th Cir. 1955).

yet so that the purchaser can move directly against the bottler in warranty, except in the vending machine where the bottler is the retailer. There is a vending machine case holding that there is a sale from the bottler to the user when the user puts his dime in the vending machine, if it is the bottler's own vending machine.⁷ A different rule would apply if the bottler sells to a service company that runs the vending machine concession, of course. However, the bottler may be liable in warranty to the retailer where the purchaser sues the retailer in warranty and the retailer loses the case. Ohio has held in one case that the retailer is liable in breach of implied warranty to the purchaser who has bought the bottle and who has suffered an explosion of the bottle while in his possession.⁸

In the negligence case which will be the primary route of liability against the bottler, the plaintiff will have to show that the bottler failed to use due care. This normally will mean showing that there was a defect in the bottle that could have been seen with careful inspection. That there was no careful inspection is easily proven because there never is. The great hurdle for the plaintiff will be proximate cause; that is, it will be the affirmative duty of the plaintiff to negative abuse and mishandling of the bottle after it left the bottler's hand. Let us assume you have a case where all the bottle fragments have been retained and the bottle has been reconstructed. We find the type of fracture; we find an internal pressure fracture; we find a mark of damage, typically internal damage; and then we find there was a light bump on the bottle. This is a case that should be won. Perhaps we should add to the technical discussion that the fracture is almost always associated with a defect on the opposite surface of the glass. That is, against over-carbonation, the significant defects are on the outside of the glass; while against mild impact, the significant defect will be on the inner wall of the glass. Every glazer knows this. The impact on the opposite side from the scratch produces the damage.

My friend, Tom Lambert, is fond of saying that torts have birthdays. Suppose you don't have the bottle or any piece of it; not even the cap. What then? Then your only hope is *res ipsa loquitur*, and this tort's birthday is 1912: *Payne v. Rome Coca-Cola Bottling Co.*⁹ The significant portions of the opinion say that since the bottle exploded, inferentially someone was negligent. The man who handled the bottle said he handled it carefully. The delivery boy said he handled it carefully. The grocer said he handled it carefully. The trucker said he

⁷ Mead v. Coca-Cola Bottling Co., 329 Mass. 440, 108 N.E.2d 757 (1952).

⁸ Mahoney v. Shaker Square Beverages, Inc., 64 Ohio L. Abs. 200, 102 N.E.2d 281 (C.P. 1951).

⁹ 10 Ga. App. 762, 73 S.E. 10887 (1912).

handled it carefully. Well, who was negligent? The last man who had it was the bottler. The court said he can come in and say he was not negligent either, and then it would be a jury question. But if everyone else was not negligent, then the someone, inferentially, was the bottler. Now this is the heart of the *res ipsa loquitur* doctrine. Some states say that they do not apply it at all. But even these states, or the majority of them, will say you may draw the inference of negligence from the circumstances that the bottle exploded and everyone that handled it handled it carefully after it left the bottler, which reaches the same result by giving it a different name. The Ohio cases on the *res ipsa loquitur* principle start with *Birn v. Coca-Cola Bottling Corp.*,¹⁰ in which Judge Harris looked at an exploding bottle case and read the defense brief which showed that there were four jurisdictions that denied *res ipsa loquitur* and only two that permitted it. His conclusion was that counting ended the question. He wrote a little opinion saying four-to-two; now it's five. The next Ohio case was *Curtis v. Akron Coca-Cola Bottling Co.*,¹¹ in which the plaintiff lost a bursting bottle case; but *res ipsa loquitur* was not even invoked by plaintiff's counsel. He hadn't even counted the two jurisdictions, and submitted no proof of careful handling.

The leading case is *Fick v. Pilsner Brewing Co.*¹² There a bartender at Micky's Tavern was unloading a case of beer to put it in the cooler, the beer having been stored in the basement for two days. He was lifting two bottles at a time, one in each hand. As he lifted them out of the case and headed for the ice box, one blew up and put out his eye. Two men who had brought the cases of beer up from downstairs and put them under the bar for the night's use testified they handled the beer carefully, and that they had been there when the drivers from the beer truck brought the beer in and put it in the basement. The Tavern's employees didn't handle it at all, so the last contact was contact by the defendant brewing company's own drivers. On that basis, with a showing of careful handling after it left the bottler, Judge MacNamee ruled that the case could go to the jury, and the jury returned a verdict for the plaintiff. On the motion for new trial, extensive briefs were filed with a new count of jurisdictions. As I remember it, by that time, the old score of four-to-two had turned around to be about eighteen-to-five. Judge MacNamee didn't just count noses however. He gave the problem thoughtful analysis and addressed himself to the idea that in *res ipsa*, classically, the defendant must be in exclusive possession and control of the instrumentality. Obviously,

¹⁰ 13 Ohio L. Abs. 727 (C.P. 1933).

¹¹ 31 Ohio L. Abs. 546 (Ct. App. 1939).

¹² 54 Ohio L. Abs. 97, 86 N.E.2d 616 (C.P. 1948).

Pilsner Brewing was not in exclusive control of the bottle when it blew up. The bartender himself had control; he had the bottle by the neck. Judge MacNamee wrote a sound analysis which is still valid Ohio law and is certainly the law of most jurisdictions in the United States today:

A manufacturer or processor may create and set in motion the causative force of an injury which those subsequently in possession of the offending product are powerless to control. It is difficult to perceive a difference in principle between these latter cases and those where a defendant's sole power to prevent injury, by the exercise of reasonable care, results from his exclusive possession and control of the offending thing at the time of the occurrence. In both classes of cases the defendant has exclusive control of the causative force of the injury. Whether this essential control results from manufacturing, processing or compounding a produce, or inheres in defendant's exclusive possession and control of the offending thing at the time of the injury would seem immaterial. In either such circumstance there is equal warrant for the application of the doctrine.¹³

Note then that to make a *res ipsa* case go successfully (and two or three of them have been lost in Ohio since *Fick* by counsel who thought all they had to do was to show that the bottle blew up), it takes proof that the causative force of the injury was a causative force in the control of the manufacturer. This makes it absolutely mandatory that the plaintiff prove careful handling and careful use of the bottle from the time it left the bottler's hands. Now by careful, we don't mean gingerly. The bottle can have normal use and normal abuse; it can be scuffed around on the counter, it can be knocked over. Bottles are treated that way. Look at any vending machine and watch them rattle down the chute to the bottom. The bottle is supposed to take this kind of handling and abuse, but it is not supposed to be dropped off the counter to the floor. Normal handling and normal use from the time the bottle leaves the bottler is essential to the case. This proof is sometimes difficult to obtain if the bottle comes from a grocery store. We sometimes find that the store clerks are a little dim in their memory of how they handled the bottle. The practical answer to this problem is to sue the retailer in implied warranty and sue the bottler in negligence. The warranty case is again going to require the proof of normal handling to prove that the proximate cause of injury was the breach of warranty. But here the purchaser says, "I handled it carefully when I bought it at the grocery." Therefore, there is a breach of warranty when the bottle explodes while he is handling it carefully. Under these circumstances the ingenuity and the investigative

¹³ *Id.* at 105, 86 N.E.2d at 621.

abilities of counsel defending the retailer will lead him to find the clerks who had handled that bottle. And they will find that those clerks remembered how carefully they had handled the bottles.

Now what is the situation as to non-carbonated beverages? *Res ipsa* will not apply to non-pressure vessels such as milk bottles, mayonnaise bottles, or pickle bottles. Here plaintiff must prove actual defect since there is no exclusive control of the causative factor in the manufacture.

In pleading and proving your case, if there is a specific defect that you know about, of course it should be laid out. If you do not know what the defect was and do not have all the pieces of the bottle so you will never be sure, then plead it as a *res ipsa* case. We have already indicated the great desirability of joining the bottler and the retailer. Normally plaintiff will not be able to join the manufacturer because he is not in the district, and perhaps not in the state. If he were, it might be worth while joining him just to get his expert testimony that the defect was a defect he had nothing to do with, and that no bottle could leave his plant containing it because of the infallibility of his tests. Manufacturers are very glad to give you this kind of testimony, particularly when they are defendants in the law suit. "Infallible" testimony all comes out of cases where the manufacturer was sued, not out of cases where the bottler was sued. It is essential in any of these cases to inspect the plant so that you will know how that particular plant operates. Most trial judges in Ohio would give you this right of inspection upon suitable motion. It was given to the trial counsel in the *Pick* case. When you are in the plant on inspection, take careful note of how things are done and the rate at which bottles explode. You should find it a very surprising experience, and this might lead you to believe that a jury view is desirable so that the jurors can hear the same ringing racket. A fruitful source of inquiry in your investigation of the cases is, as I indicated earlier, the small retail dealer in carbonated beverages who keeps an adequate supply in his back room. The bottles burst just standing in the case back there—a substantial number every week. If there is a great deal of breakage of a particular product and you have one of those products, this kind of evidence of an unusual amount of bursting is admissible even under a straight *res ipsa* approach, as making it more likely than not that the causative force of the explosion was something in the bottle, rather than something that happened in the consumer's hand.

A final word on the policy questions involved here: When we deal with *res ipsa loquitur* we are saying that the bursting bottle is something which would not happen if ordinary care were used. This will require us to define ordinary care quite closely because the way the American

bottling industry operates in a way which ordains that a substantial number of bottles will burst every year. We cannot realistically say bottles will not break if due care is used, unless we say that the risk of the punctured eyeball is so great that some careful inspection of each bottle ought to be made. This invokes the reasoning of *Ault v. Hall*,¹⁴ in which our supreme court said that long-continued custom and practice cannot avail to make safe in law that which is dangerous in fact. The policy of using and re-using bottles that are subject to all kinds of abuse in the field, and putting those bottles into washing equipment which inevitably gives them further internal abuse which is the most dangerous kind of damage, and then filling them and sending them out without any real inspection for nicks, cracks, gouges, chips, and all the things that produce stress concentration, fatigue, and failure in normal use, is a policy which is dangerous in fact. It is economically profitable, however. In fact the bottler will say that if he must inspect every bottle, he will go out of business. The policy answers here should be that either the bottler should use throw-away bottles or cans, or if it is his deliberate choice that it is economically more profitable to re-use the old, abused, internally damaged bottles, knowing that there is risk, and choosing to take this risk, then he should pay the victims of the risk. It seems to me that this makes good morality and good sense. A lot of bottles break with no one being injured. When an occasional bottle does break with injuries as serious as blindness, then I think it is no answer for the bottler to say he would have to spend two minutes or two cents inspecting every bottle the way it ought to be inspected. We know it *ought* to be inspected that way because of the danger in it. The carbonated beverage bottle is a potential bomb. So long as they are not inspected that way, then the application of *res ipsa loquitur* is entirely sound and right. The burden of the occasional disastrous loss should be spread back to the industry by the *res ipsa loquitur* route.

¹⁴ 119 Ohio St. 422, 164 N.E. 518 (1928).